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AUTHOR Brown, William J.
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ABSTRACT

Current interest in the content and methodology of college physical science instruction stems from a recently adopted general education program for Montgomery College, a two-year comprehensive community college. It is contended that physical science should play a major and vital role within the science component requirements of a student's program and that a course may be designed to foster many of the outcomes usually associated with a "broadly educated person." These qualities include: effective communication skills; critical thinking skills; problem-defining and problem-solving skills; and the ability to read, understand, and logically discuss how things work for social as well as for natural systems. This paper, although physical science oriented, provides information of a historic and contemporary nature useful for those seeking new directions in implementing science components for general education programs. Past and present textual and curriculum materials are also examined, focusing on materials appropriate for the physical science component of general education programs. The guided design strategy is discussed (and recommended) since the approach may foster development of the desired outcomes of physical science in general education programs. Guided design, a decision-making/critical thinking strategy, involves course activities organized around the solution of a series of open-ended problems. (JN)

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PHYSICAL SCIENCE IN GENERAL EDUCATION CURRICULUM REFORM

WILLIAM J. BROWN, PROFESSOR

DEPARTMENT OF PHYSICS/ENGINEERING/GEOSCIENCE

MONTGOMERY COLLEGE

ROCKVILLE, MD 20850

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INTRODUCTION

A current interest in the content and methodology of college physical science instruction stems from a recently adopted general education program for Montgomery College, a two-year comprehensive community college. It is contended that physical science should play a major and vital role within the science component requirements of a student's program for learning opportunities for this course may be designed to foster many of those outcomes usually associated with a "broadly educated person." Those qualities include: effective communication skills, critical thinking skills, problem defining and problem solving skills and the ability to read, understand and logically discuss how things work for social systems as well as for natural systems.

The intent of this writing, even though physical science oriented, is to provide information of a historic and contemporary nature useful for any seeking new directions in implementing science components for general education programs. Certain of the instructional technology described may equally serve disciplines other than physical science.

HISTORICAL PERSPECTIVES

A committee was formed by the American Association for the Advancement of Science in 1939, to identify problems involved in adapting science to the requirements of general education at the college level. [1]

The outcome of this study, a statistical one based upon opinions of 1000 college teachers, provided interesting findings some of which may prove relevant for our contemporary review.

Selected findings of the committee were:

1. More than 2/3 of the teachers felt their offerings were justifiably less than acceptable to students whose interest in the subject was not primarily professional.
2. The general courses being taught were aimed at the minority of students who would later specialize.
3. The general courses were disregarding the best interests of the non-specializing majority of students.

Additionally:

4. Critically thinking was identified as the most significant contribution the course could make.
5. Few college science teachers make any attempt to change their mode of presentation or evaluate in any way outcomes of science instruction.

The implications for teaching show that: science courses must be designed with general education in mind and more attention must be paid to general education students because these students are candidates for general education before they are candidates for professional education and if preparation is to be more extensive, it should be that of a candidate for general education.

In 1949, Bullington, [2] conducted an ambitious survey of 967 four year colleges and universities attempting to determine the status of science courses in general education, the types of courses available and the objectives. His findings included a severe lack of science textual materials as well as a dearth of qualified teachers who could teach accross disciplines.

CONTEMPORARY REVIEW

Jerry Gaff, in his book General Education Today, [3] has discussed briefly but succinctly the essential role of science in the general education program for all students. He has quoted from a National Research Council finding (1982) that, " failure to acquaint non-specialists with the basics of science is an educational problem of national proportions." The Research Council further found that the adequacy of the offerings is very much open to question-that typical science courses are packed with only factual information. Gaff provides other information from a recent Columbia University report which acknowledges that in the 62 years of the founding of the Columbia General Education Program, science has never been successfully integrated into the core curriculum.

There are certain issued which Gaff believes are germain to the question of the introduction of science into the core. The three issues yet to be resolved are: a. The scope of courses for non-majors. b. Whether to teach science or teach about science. c. Whether courses should stress content or methodology and the nature of scientific thought. [4]

A complication in the debate of late is that those who call for computer and technological literacy have overshadowed the voices of science literacy for all.

TEXTUAL AND CURRICULA MATERIAL PAST AND PRESENT

There has been a select few individuals who have attempted to resolve some of the issues raised amid a background of seemingly much confusion and controversy in implementing a sound science component (physical science)

of a general education program.

The following four authors are mentioned because they have cited their interest in general education as the cause for writing materials appropriate for the physical science component.

In 1952, Gerald Holton of Harvard University, recognizing the discussion having taken place with regard to the form and function of introductory science courses for college undergraduates, wrote a text titled Introduction to Concepts and Theories in Physical Science, in which at least some of the old conventionalities of science text writing were abandoned. [5]

While the focus of Holton's text was still a firm knowledge of fundamentals, there were other aims as well. Science was presented as an experience—as an integrated intellectual adventure. Instead of just facts, methods and approaches, explicit was how science principles, laws, and theories were first formulated. The whole of the text was set within a historical context. The authors express purpose for writing such a text was his eagerness to provide the Liberal Arts, general education student an alternative to the specialized science courses from which they had to select. To quote Holton, "The commitment, motivation and long range interest in specialized courses for these students (Liberal Arts) is much attenuated. He does not plan to devote his life to science and hence the science course taken may well be the first and the last formal contact with the subject."

This text, sometimes called the " grandfather" of contemporary physical science texts, deserves recognition for reasons other than the philosophic perspective provided.

Originating in 1956, the Harvard Case Studies edited by James Conant, were designed primarily for students majoring in the humanities and social sciences. A series of eight case studies were written in an effort to assist the student in recapturing experiences of those scientists who actually participated in making scientific history. These case studies covered major science advances from the 18th. century into the early 20th. century. [6]

Each study was designed to explore the methods of science, to define pure and applied science, to discuss experimentation and how science advances the progress in the practical arts. It was Conant's opinion that an understanding of science, independent of a vast knowledge of scientific facts, is required to understand related developments in other fields of human activity.

Gerald Holton and Duane Roller [7] collaborated in 1958 to produce a physical science text with the same approach to the study of physical science as Holton had done (1952) but with appeal to a wider group of students. This new text was to develop the mathematical and conceptual materials of science more extensively. The text also was to provide more material on the modern aspects of physics, e.g., physical optics, quantum optics, and nuclear physics.

In addition, the textual material imparted some of the scientists' characteristic curiosity about the physical world and the limitations of science in solving problems. The text was intended mainly as a one-year general physics course or a course for majors in the humanities and social studies and the integrated or general education course.

It is the opinion of this writer, who has taught physical science for some thirty years, there are presently instructional technologies and science curricula material available which may well represent that for which general education promotors have been searching--material whose learning outcomes satisfy the major goals of general education cited in the introduction to this paper.

Guided Design, a decision making/critical thinking instructional strategy, was developed at West Virginia University in the late 1960's by Charles Wales and Robert Stager [8] as a better way to teach engineering. It soon became apparent the concept of Guided Design could be adapted to many if not most disciplines at the undergraduate if not the graduate level of instruction.

Guided Design course activities are organized around the solution of a series of open-ended problems. Each problem is designed in such a way that to arrive at a solution, the students must apply the subject matter they are learning in the course. Activity starts with an instruction that describes a problem situation and specifies the role the students (usually five to six in a group) are to play. The students are ask to identify the real problem and set the goal for their work. After group members agree on an answer, the result is compared with a printed "feedback" page which shows how others have responded. Students then consider their answer in the light of other viewpoints.

The solution isn't the important factor --the process is. The students can learn to base their beliefs on evidence (as distinct from dicta oft found

in lecture courses) and that professionals serve only as guides.

Personal experience has shown that combining a Guided Design approach with a science text as Physical Science, 2nd. Ed. by Turk and Turk, provides for an extremely effective teaching-learning combination.

The Center for Guided Design is established at West Virginia University with Dr. Charles Wales as director. The Center is supported by an Exxon Education Foundation grant which also funds teacher workshops in Guided Design. The literature supplied by the Center lists those institutions, disciplines and contact persons currently using Guided Design as an instructional technique.

Charles Wales and Gene D'Amour developed an extensive course, based upon the paradigm of Guided Design, called the Nature of Evidence. [9.] This course stresses the similarities and differences between the methods of gathering evidence used in natural sciences, social sciences and the humanities—these three areas happening to be the core of most general education programs.

The course assists students in understanding the decision making and evidence gathering procedures of the core area courses. The course consists of the use of two volumes: Volume A, Design Projects: Displaying the Evidential Method and Volume B, The Role of Evidence: Exploring the Evidential Method.

The Nature of Evidence as a course is designed for the professional (specialist) as well as for the non-professional (generalist). While group dynamics is central to the operation, Part B can be taught by Personalized

Instruction techniques. Other instructional strategies such as team teaching may be employed as each area of chemistry, anthropology, and drama is taught by the expert in that field.

The third and fourth pieces of uniquely different science curricula material comes from Arnold Arons of the University of Seattle. [10, 11] Arons has been much concerned about the reasoning abilities of undergraduate college students which he says are "commonly and inappropriately assumed to exist in most text materials, homework and lecture presentations which the student encounters in natural sciences, social science and the humanities. Arons makes explicit his assumptions in an artle titled, "Some Thoughts On Reasoning Capacities Implicitely Expected of College Students."

A major portion of Arons' identification of assumed capacities and abilities include: Recognition, Identification and Control of Variables; Arithmetical Reasoning; Forming and Comprehending Propositional Statements; Ability to Paraphrase a Paragraph of Text in One's Own Words; Awareness of Gaps in Knowledge or Information; Understanding the Need for Operational Definitions: Translating Words into Written Symbols and Written Symbols into Words; Discriminating between Observation and Inference; Drawing Inference from Data and Evidence; and Developing Self-consciousness Concerning One's Own Thinking and Reasoning Processes.

The ideas developed by Jean Piaget are taken up by Arons in his writing of a physical science text, Inquiry in the Physical Sciences. The text is written in such a way that students move from concrete experiences toward abstraction while allowing time for contemplation, revision of

mistakes, and numerous repetitions of any one kind of logical reasoning, e.g., retesting. The design of this physical science text is such that student growth is encouraged in the areas where Aron's assumptions have been made.

The text material provides historical and philosophical perspectives toward the nature, origin, power, and limitations of scientific thought, while at the same time the textual material covers much of the physical science content of the principal elementary science curricula.

The thesis of Aron's work is that the citizenry of this country must be a thinking, reasoning citizenry and urges colleges to commit themselves to that type of educational framework designed to develop reasoning capacities.

CONCLUSIONS

Major publishers of physical science textual and other curricular materials have produced little in the way of science materials useful for science components of the present day general education curriculum reform movement. Writing and the use of any such material appears at best to be highly localized. It may be assumed the dearth of available material is in part due to a reluctance of publishers to produce for a potentially limited market. Publishers perhaps remember a prior science curriculum reform movement of the 60's, when certain federally funded science programs as CHEM Study and The Physical Science Study Committee (PSSC) materials were less than 50% adopted by the nations secondary schools.

Many college science departments yet consider a survey course as Physical Science suspect in being "watered down." Courses taken from

science disciplines are offered as the science component in many general education programs.

There is a mode of science instruction worth trying. Meld the work of Arons with that of Wales and the outcomes should meet or exceed the expectations of any college administration and or general education course selection committee.

Finally (with no apology) and perhaps not the least important reward for a successfully implemented physical science component, the instructional dean may invite you to her/his office for a late P.M. coffee and a personal chat--you have been noticed.

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